EXPERIMENT 7
Effect of Temperature on Equilibrium

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REACTION OF INTEREST	$Fe^{3+}\,(aq) + xSCN^{-}\,(aq) \rightleftharpoons [Fe(SCN)_x]^{3-x}\,(aq)$

MAIN PURPOSES

Constancy of the value of K (independent of initial concentrations)

Dependence of K on temperature

Determination of $\Delta H°$ and $\Delta S°$ for this reaction

PART 1: DETERMINATION OF THE VALUE OF ε

Spectrophotometry to determine $[Fe(SCN)_x]^{3-x}$

Beer-Lambert Law: $A = \varepsilon c \ell$

Prepare three calibrating solution with known $[Fe(SCN)_x]^{3-x}$

↓

Measure their absorbances at a chosen wavelength

↓

Plot Absorbance vs. $[Fe(SCN)_x]^{3-x}$

↓

Determine ε from the slope

PART 2: STOICHIOMETRY OF THE COMPLEX FORMATION

Use Job's method to determine x in $[Fe(SCN)_x]^{3-x}$]

Beer-Lambert Law: $A = \varepsilon c \ell$

If the product is a 1:1 complex (x = 1), maximum amount of product is formed in solution with mole fraction of SCN^- = 1/2

↕

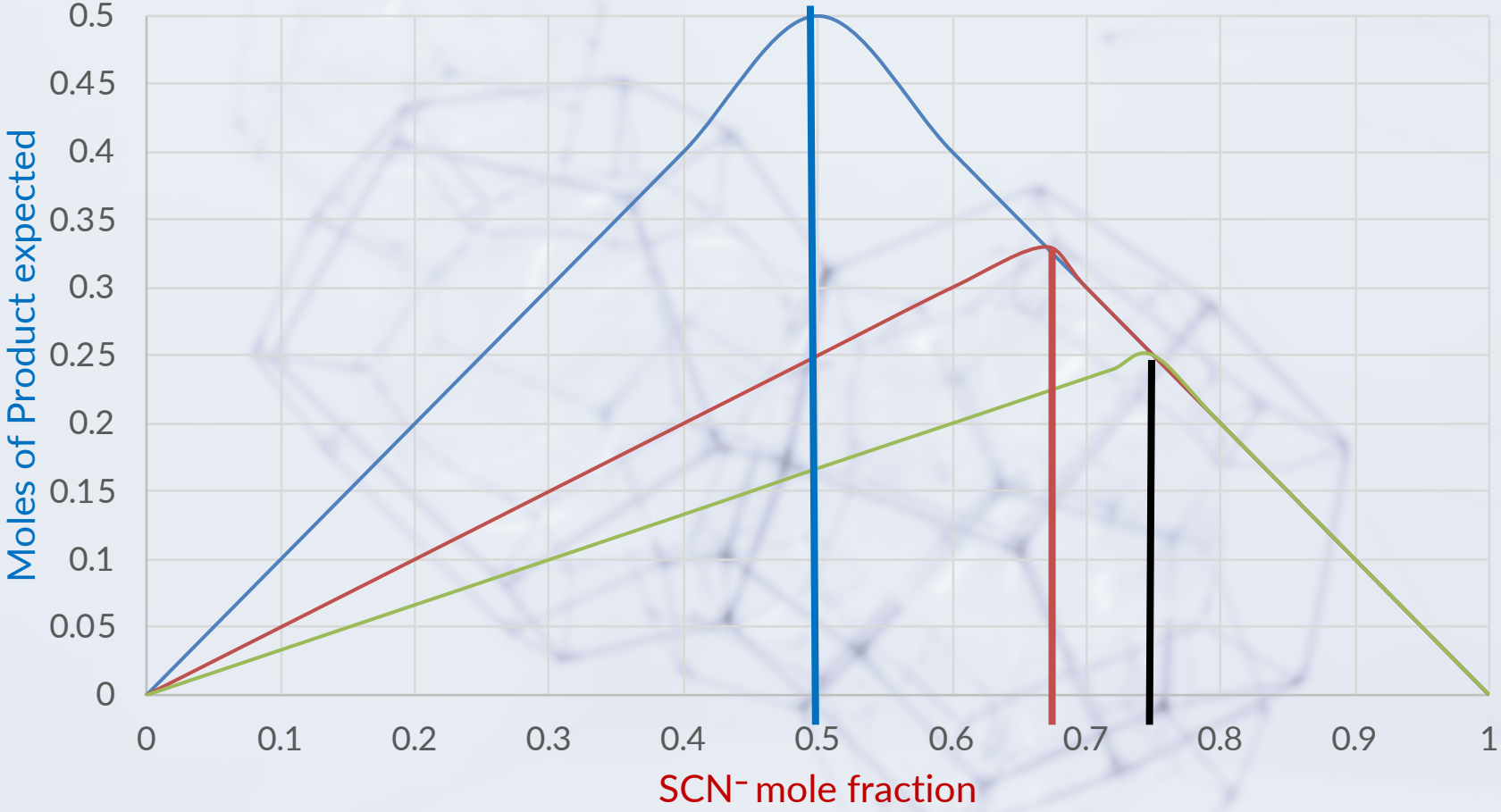
If the product is a 1:2 complex (x = 2), maximum amount of product is formed in solution with mole fraction of SCN^- = 2/3

↕

If the product is a 1:3 complex (x = 3), maximum amount of product is formed in solution with mole fraction of SCN^- = 3/4

This prediction "always" holds true

EXPECTED RESULT



PART 3: CONSTANCY OF THE VALUE OF K (INDEPENDENT OF INITIAL CONCENTRATIONS)

Can you write the expression for K for this reaction?

How can we determine the three needed concentrations?

Determine $[Fe(SCN)^{2+}]_{eq}$ experimentally using Beer-Lambert Law

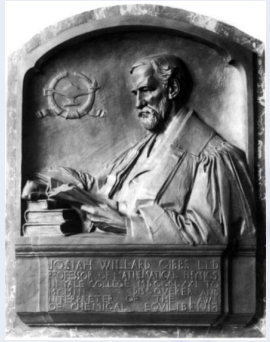
Apply atom conservation (material balance) to calculate:

$[Fe^{3+}]_{eq}$ and $[SCN^{-}]_{eq}$

For example:

$[Fe^{3+}]_{eq} = [Fe^{3+}]_0 - [Fe^{3+}]_{consumed} = [Fe^{3+}]_{eq} = [Fe^{3+}]_0 - [Fe(SCN)^{-}]_{eq}$

PART 4: EQUILIBRIUM CONSTANT AND TEMPERATURE



$\Delta G° = \Delta H° - T\Delta S°$

Gibbs Relation

$\Delta G° = -RT \cdot \ln(K)$

Van't Hoff Equation

Yale

Plot of ln(K) vs. 1/T is expected to linear.

SLOPE = $-\Delta H°/R$

Y-INTERCEPT = $\Delta S°/R$

In part 3, what is the role of KNO_3?

NOTES

1. Part 1: three solutions (1–3)
   Part 2: nine solutions (A–I)
   Part 3: five solutions (J–M; *save L or M*)

Make solutions first, then take spectra!

2. Part 1: Beer-Lambert plot – accuracy grade
   → Pipet and syringe with care
   → Avoid contamination and/or mislabeling

3. Calibrate the digital thermometer in ice + water mixture

4. Part 4: measure absorbance and temperature
   → Try to measure them "simultaneously"
   → Data collection duration (< 20 sec)
   → 4/5 temperatures *below* room temperature
   → 5/6 temperatures *above* room temperature

10+ temperatures total